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Radiological Survey of Ingalls Shipbuilding Division Pascagoula, Mississippi, and Environs

(U.S.) Eastern Environmental Radiation Facility
Montgomery, AL

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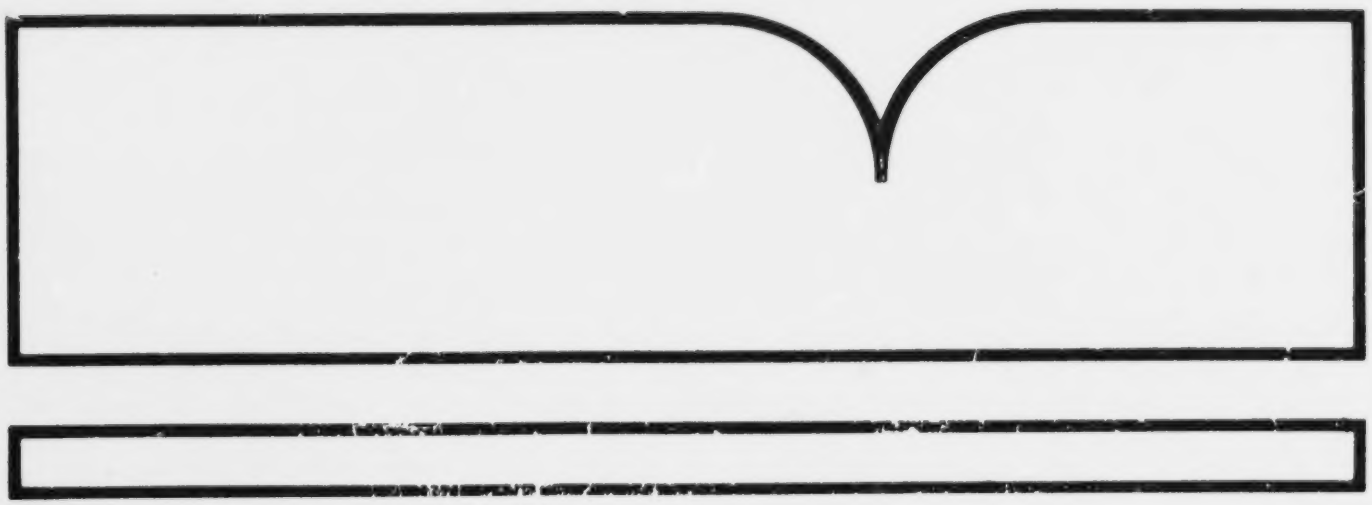

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This report presents results of the survey conducted by EERF personnel to assess environmental radioactivity remaining from operations of nuclear-powered vessels at Ingalls Shipyard, Pascagoula, Mississippi. Since Ingalls shipyard will no longer build or service nuclear powered ships and has completed the decommissioning of the nuclear support facilities, an additional purpose of the survey was to determine if there is any remaining radioactivtiy from previous operations which could contribute to significant population exposure.

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RADIOLOGICAL SURVEY

OF

INGALLS SHIPBUILDING DIVISION, PASCAGOULA, MISSISSIPPI,

AND ENVIRONS

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August 1982

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TABLE OF CONTENTS

List of Illustrations. iii

Preface v

Acknowledgements vi

Introduction 1

Characteristics of Ingalls Shipbuilding Site 2

Survey and Analytical Methods 8

Results and Discussion 13

Conclusions 39

References 41

Appendix 1 Sediment Sample Analysis Results 42

Appendix 2 Core Sample Analysis Results 51

Appendix 3 Sampling Locations in SORB 64

LIST OF ILLUSTRATIONS

FIGURES

		page
1	Map of General Area	3
2	Map of Survey Locations Offsite	4
3	Map of Sediment, Probe, and Water Sample Sites	5
4	Map of Core Sample Locations	6
5	Map of Shoreline Gamma Measurement Sites	7
6	East End of SORB: First Floor Paint and Concrete Samples . .	64
7	West End of SORB: First Floor Paint and Concrete Samples . .	65
8	Center of SORB: First Floor Paint and Concrete Samples . . .	66
9	East End of SORB: Second Floor Paint and Concrete Samples .	67
10	Center of SORB: Second Floor Paint and Concrete Samples . .	68
11	West End of SORB: Second Floor Paint and Concrete Samples .	69

TABLES

1	Results of Aquatic Life Sample Gamma Analyses	15
2	Results of Water Sample Analyses	16
3	Gamma Shoreline Measurements	17
4	Paint Samples with Detectable Gamma Activities	21
5	Gamma Activity in Concrete Samples	24
6	Surface Contamination Sampling Sites for Beta Analyses . . .	26
7	Surface Contamination Sampling Sites for Tritium Analyses . .	27
8	Air Sampling Sites	28
9	Gamma Activity in Soil Samples	29

LIST OF ILLUSTRATIONS--continued

		page
10	Results of Miscellaneous Sample Analyses	33
11	Results of Asphalt Sample Gamma Analyses	34
12	External Gamma Radiation Measurements Inside SORB	35
13	Travel Routes for Power Units	37
14	Gamma Measurements in Other Shipyard Locations	38

PREFACE

The Eastern Environmental Radiation Facility (EERF) helps solve problems defined by the Office of Radiation Programs. The Facility provides capability for evaluating radiation sources through environmental studies, nationwide surveillance, and laboratory analysis. The EERF also provides special analytical support for Environmental Protection Agency Regional Offices and other federal government agencies as requested as well as technical assistance to the radiological health programs of state and local health departments.

This report presents results of the survey conducted by EERF personnel to assess environmental radioactivity remaining from operations of nuclear-powered vessels at Ingalls Shipyard, Pascagoula, Mississippi. Since Ingalls shipyard will no longer build or service nuclear powered ships and has completed the decommissioning of the nuclear support facilities, an additional purpose of the survey was to determine if there is any remaining radioactivity from previous operations which could contribute to significant population exposure.

Readers of our reports are encouraged to bring comments, omissions or errors to our attention.

Charles R. Porter, Director
Eastern Environmental Radiation Facility

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The authors gratefully acknowledge the U.S. Naval Sea System Command staff and Ingalls staff that assisted us in identifying areas which were previously used for radioactive work so tht EERF could select locations for collecting samples and making measurements. We also thank Eddie Fuente and Greg Dempsey of the Mississippi State Board of Health for participating in the survey.

INTRODUCTION

Since 1963, the Eastern Environmental Radiation Facility (EERF), U.S. Environmental Protection Agency (USEPA), in cooperation with the U.S. Naval Sea Systems Command (NAVSEA) has conducted several surveys of ports serving nuclear powered vessels on the Atlantic, Gulf, and Pacific coasts, including Pearl Harbor (Ca77, Ca79). These surveys assessed whether nuclear powered vessel operations, including berthing, repair, and servicing, have created elevated levels of environmental radioactivity. The surveys emphasized sampling those areas and pathways that could result in significant exposure to the public.

Ingalls Shipbuilding Division (ISD), Pascagoula, Mississippi, was surveyed by EERF personnel in December 1981. This was the first survey of this facility by the EPA in its series of harbor surveys. The survey was requested by NAVSEA in conjunction with Ingalls' plan to decommission the ISD, which has discontinued work on nuclear powered vessels. Two main areas were surveyed: the harbor and the Submarine Overhaul and Refueling Building (SORB). Representatives from the Mississippi State Board of Health participated in the survey.

CHARACTERISTICS OF INGALLS SHIPBUILDING SITE (Bu75)

Ingalls Shipbuilding consists of two major facilities, one on the east and one on the west bank of the Pascagoula River where it meets the Mississippi Sound (see Fig. 1). The east bank shipyard, which has been used to construct, overhaul, and refuel nuclear submarines, is bordered on the north and east by the city of Pascagoula. The west bank facilities were not utilized in nuclear operations at Ingalls, and therefore, were not included in this survey.

The Pascagoula River channel extends into the Mississippi Sound and permits the area of the river between the shipbuilding facilities to be used by commercial shipping interests for reaching the Port of Pascagoula located north of ISD. The channel is 350 feet wide and 9.3 nautical miles long. It is maintained at a depth of thirty-eight feet at mean low tide by dredging. The river bottom is comprised primarily of sediment.

Most of the water is accessible to the public by boat with the exception of certain areas which are restricted for security reasons. There is commercial fishing in the area.

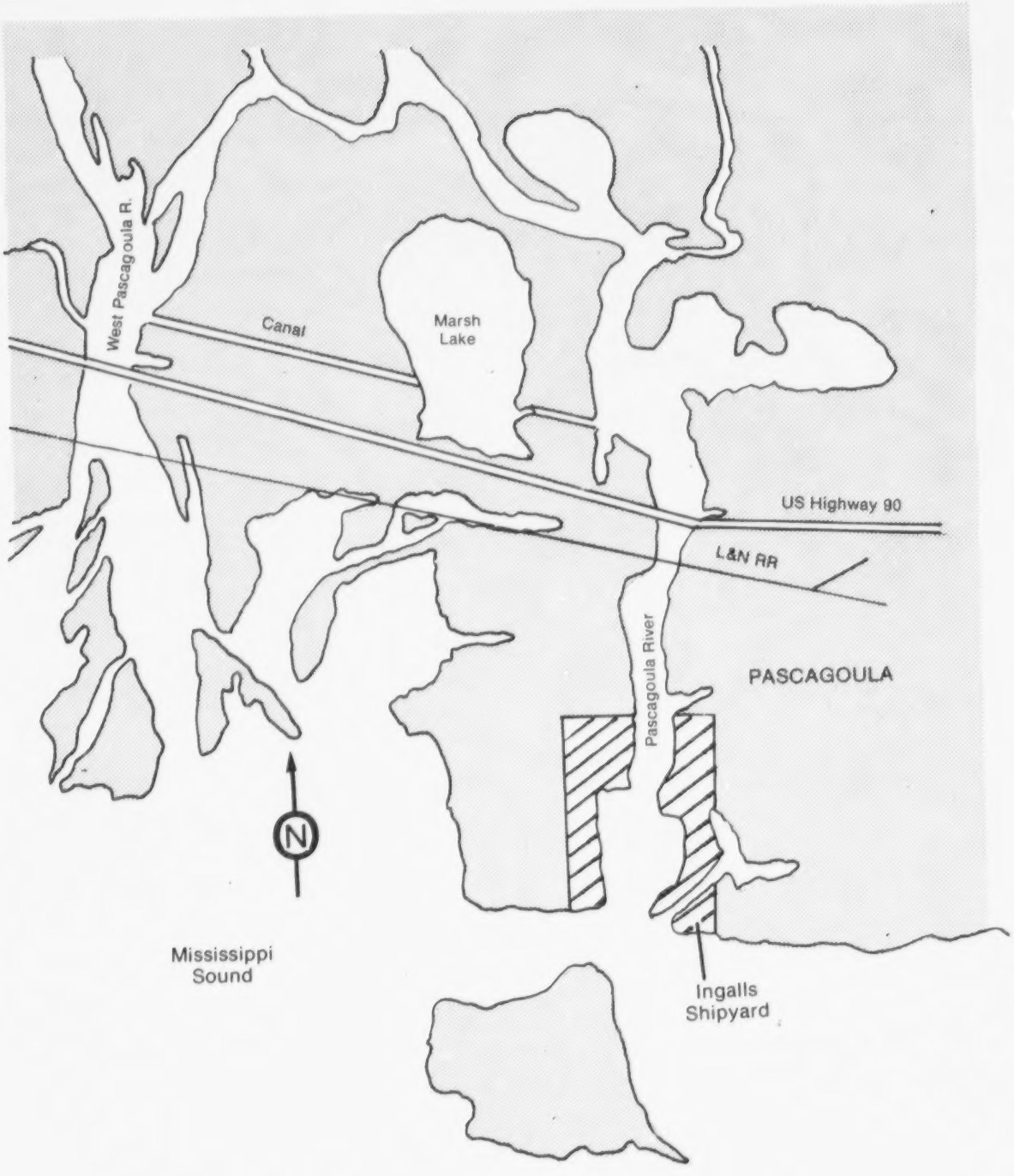

Fig . 1 General Area

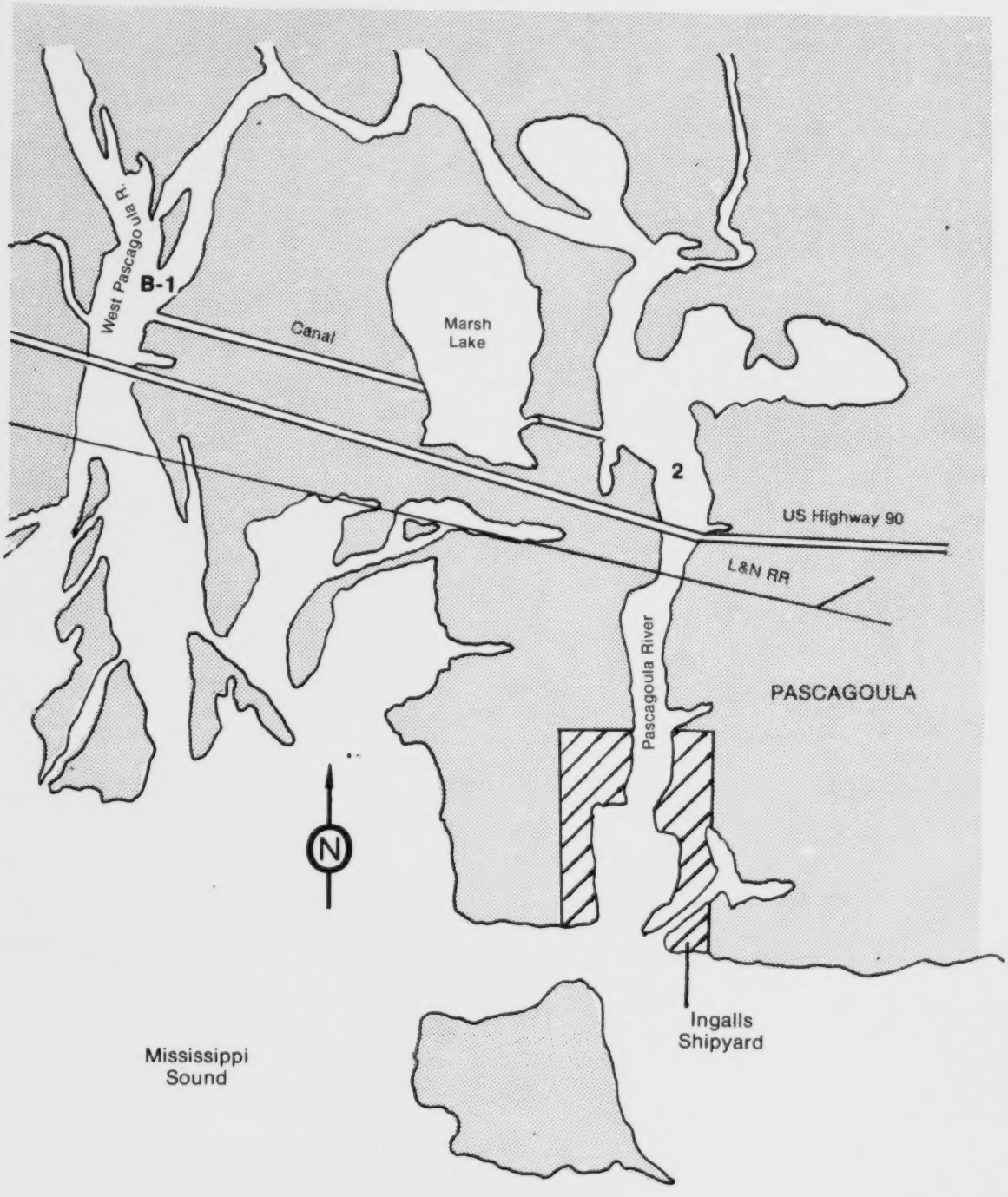

Fig. 2 Survey Locations Offsite for Background Measurements

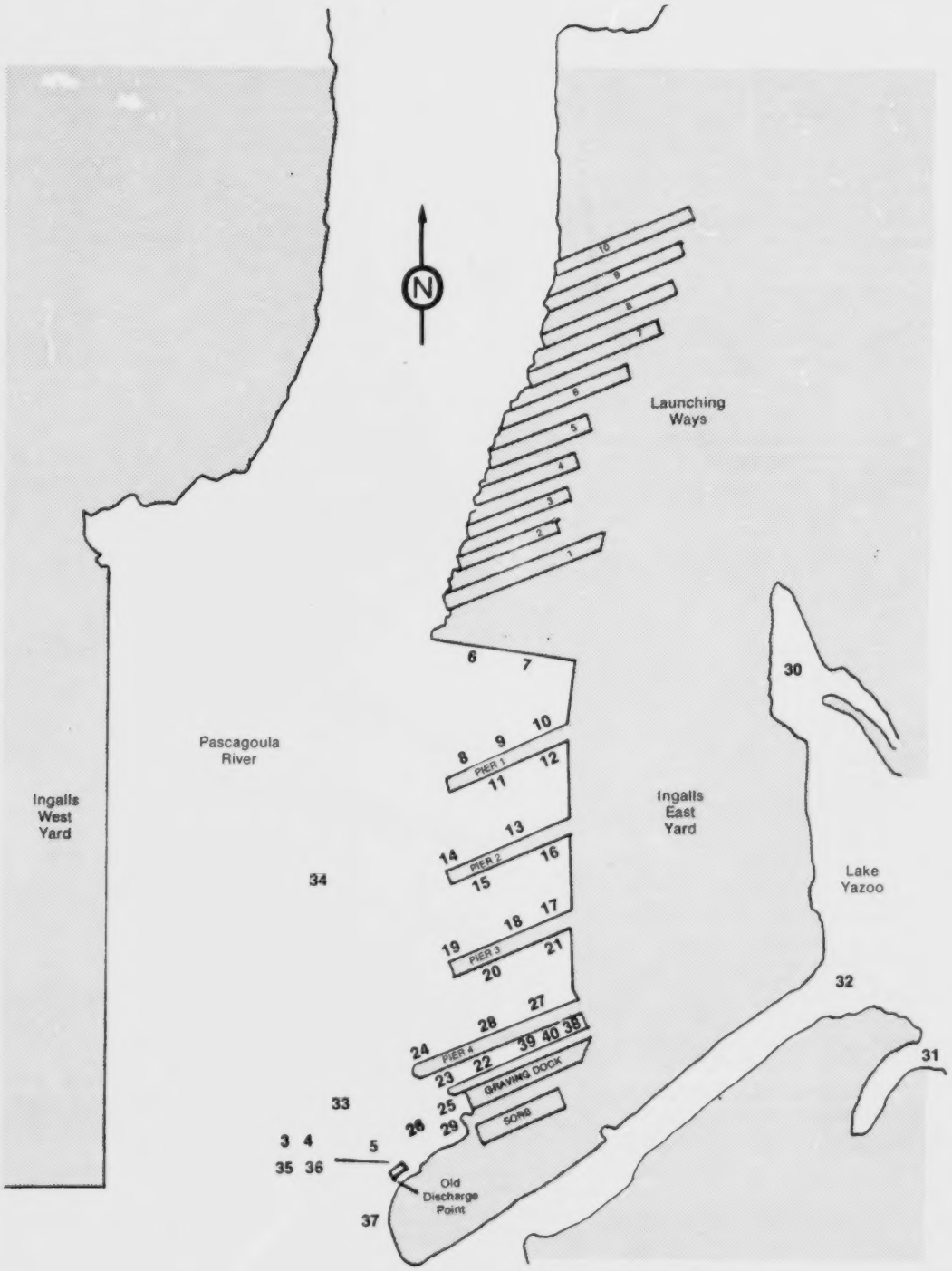

Fig. 3 Sediment Sample, Water Sample and Probe Measurement Sites

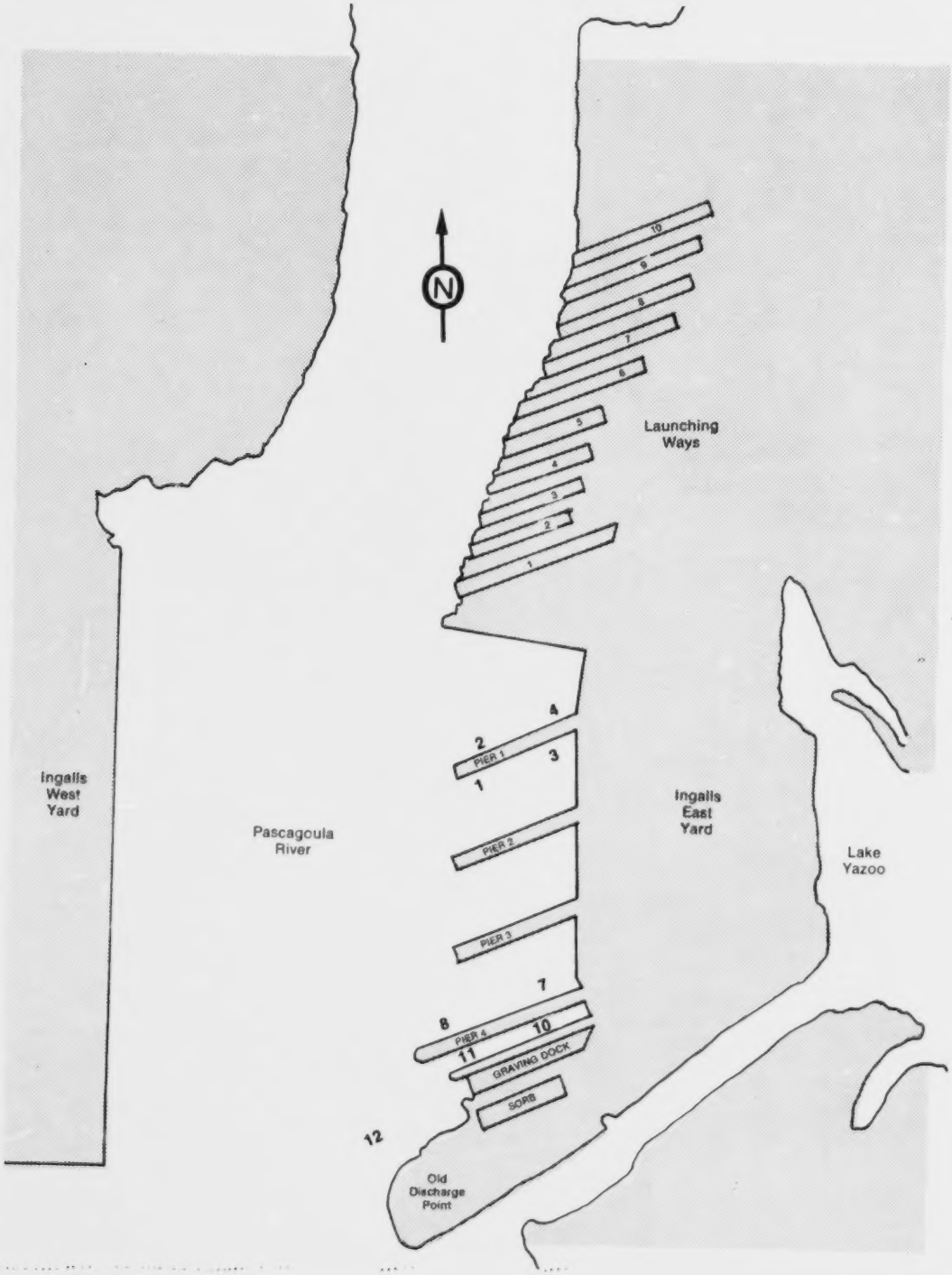

Fig. 4 Sediment Core Sample Locations

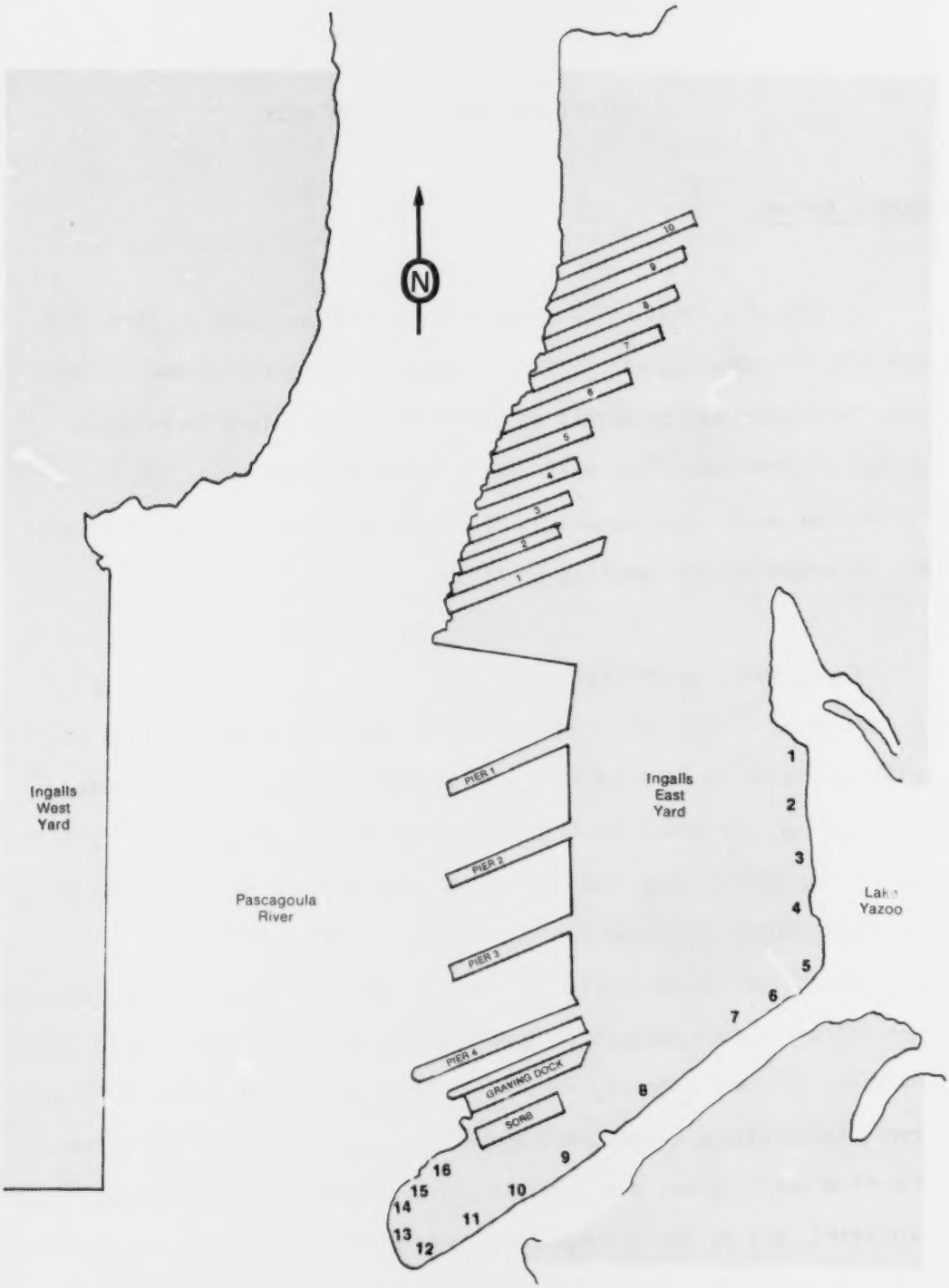

Fig. 5 Shoreline Gamma Measurement

SURVEY AND ANALYTICAL METHODS

Harbor Survey

The sampling locations covered a large area as shown in Figs. 2-5. Concentrated sampling was performed in close proximity of the ISD east bank facilities and primarily in locations where, based on shipyard operations, radioactivity most likely could be found (Fig. 3). Discussions with representatives of NAVSEA and local shipyard personnel helped determine our sampling locations.

An underwater scintillation probe utilizing a 10-centimeter by 10-centimeter sodium iodide detector was used with a 1024 channel pulse height analyzer to help locate areas of radioactivity. A 10-minute background spectrum was taken at the mouth of Mary Walker Bayou (site B-1, Fig. 2) for subtracting from counts taken at other sampling locations. All probe counts were made for 10 minutes. Locations of probe measurements are shown in Fig. 3. The underwater scintillation probe has been useful in past surveys to select areas for dredge sampling of bottom sediment. Sediment samples, identified in Table 2, were taken at locations where radioactivity seemed most probable based on shipyard operations. Extensive sampling was performed at all dry docks, berthing areas, repair facilities, and at the radioactive liquid effluent discharge point which had been deactivated in 1972. A standard Peterson dredge was used to sample approximately the top 10 centimeters of sediment. The samples were

dried at 110°C, ground to a fine powder, placed in a 400 cm^3 "cottage cheese container," and counted on a Ge(Li) or intrinsic germanium detector.

Sediment core samples in past surveys have been useful in defining the vertical distribution of radioactivity. Also, radioactive materials from past operations which were subsequently covered with sediment might be observed in the deep core samples. These samples were taken by divers at locations noted in Fig. 4. A 2.4-centimeter diameter by 61-centimeter tube was used for sample collection. The tube was pushed into the bottom as far as possible and then the ends were capped. When the core samples arrived at the laboratory, they were frozen and cut into 5.1 centimeter sections except for the first section which was sometimes 7.6 or 8.9 centimeters. The core sections were counted in the wet state on a Ge(Li) or intrinsic germanium detector.

One gallon water samples were collected at the sites noted in Fig. 3 and analyzed for gamma emitters.

Aquatic life samples, consisting of oysters, assorted small fish, shrimp, and crabs were collected where available in the area and analyzed for gamma-emitting radionuclides. Sample preparation for counting consisted of cutting and packing the material in 400 cm^3 "cottage cheese containers."

Direct gamma radiation exposure measurements were made at the locations noted in Fig. 5 using a pressurized ionization chamber (PIC) (De72). Those areas accessible to the public were of particular interest.

Survey of Submarine Overhaul and Refueling Building (SORB)

The building survey evaluated the extent of contamination of the Submarine Overhaul and Refueling Building (SORB). This building formerly housed the support systems required for overhauling and refueling nuclear powered submarines. The SORB has been surveyed and decontaminated by Ingalls in anticipation of converting it for non-nuclear activities. The Ingalls survey began in 1980 and employed a survey work force of about 100 people. The entire building was laid out in a grid system and surveys were made to ensure that walls, ceilings, floors, and pavement are below operational limits: < 450 pCi/100 cm^2 for surfaces and < 30 pCi/gm (Co-60 equivalent) for bulk material (earth, ground coverings, paint or building materials). All contaminated equipment, piping, and ventilation systems were removed and shipped offsite as radioactive waste. Therefore, the EERF survey was mainly done in empty, stripped-down rooms within the SORB which were extensively identified with grid numbers.

Gamma exposure levels were measured at appropriate locations inside and adjacent to the SORB with scintillation survey meters (Ludlum Model 12S) and pressurized ionization chambers (Reuter-Stokes Environmental Monitor Model RSS-111). In areas where there was a potential for alpha contamination, an alpha survey was done with an Eberline PAC-1SA portable alpha counter.

Air samples were collected to determine the presence of airborne gamma and beta emitters, and a mositure sample was collected to determine if

tritium was present. A high volume air sampler with an MSA dust filter was used to collect particulate gamma emitters, and a low volume air pump was used with a drierite column to collect moisture in the air for tritium analysis.

Representatives of NAVSEA and shipyard personnel indicated where they had found contamination in the SORB and also pointed out areas that had a high potential for contamination based on past shipyard operations. Paint and concrete samples were taken from these areas and the nuclide composition of any contaminated areas were determined with a Ge(Li) or intrinsic germanium detector. The sample material obtained from the walls of the rooms was mainly of two specific types: 3.5 gm paint samples and 50 gm concrete samples. Five-hundred-gram soil samples were taken under the SORB and at other possibly contaminated locations. Fifty gram asphalt samples were also analyzed. Smear samples were taken to identify any removable surface contamination. Some of the smear samples, particularly those taken in remaining exhaust system ducts, were taken using millipore HAWP 4700 filter paper. This filter material is clear when inserted into 10 ml of organic based liquid scintillation solution for counting. Counts from tritium were recorded on a liquid scintillation counter to determine tritium surface contamination.

It was recognized that gamma measurements could be influenced by materials not associated with nuclear activities at the shipyard. One such material identified was a sand used for sand blast cleaning of

metals. The material, in local jargon, was referred to as "Black Beauty" due to its dark color. This high natural radioactivity material was well distributed throughout the shipyard. A radium, uranium, and thorium analysis was done on the material to document the content of natural radionuclides.

RESULTS AND DISCUSSION

Harbor Survey

All samples were analyzed for gamma-emitting isotopes, particularly Co-60, a radioisotope resulting from nuclear operations that has been measured in past surveys. In addition, air samples were analyzed for beta activity.

Since there are commercial and sport fishing in the area, aquatic life samples were collected in the publicly accessible waters. No radioactivity (other than natural ^{40}K and ^{232}Th) above minimum detectable levels was found in any of the aquatic life samples other than a trace amount of Cs-137 (0.02 pCi/gm $\pm$ 65%) attributed to fallout. Results of the aquatic life sample gamma analyses are shown in Table 1.

The sediment sampling was the most extensive, since recent releases of radioactivity will usually be detectable in the sediment. Samples were collected at 35 locations (Fig. 3) and only a trace amount of Co-60 (0.013 pCi/gm $\pm$ 45%) was detected at Site 31. Except for the Co-60 measured at this one sampling site, the only radionuclides detected were those attributed to fallout and those which are naturally occurring as shown by the analyses of the background sample (Site B-1). Reported values for U-238 are attributed to natural radioactivity. Sediment analyses data are reported in Appendix 1.

Core samples were collected at nine locations (see Fig. 4) to determine the vertical distribution of radioactivity in the sediment. The only detectable radionuclides were naturally occurring and those which are attributed to fallout. Results of core sample analyses are shown in Appendix 2.

Water samples were collected at seven sites (see Figs. 2 and 3) and analyzed for gamma emitters. All radionuclides detected were naturally occurring. Results of water sample analyses are shown in Table 2.

Gamma shoreline measurements were made using a Reuter-Stokes RSS-111 PIC at the locations indicated in Fig. 5. Gamma exposure rates ranged from 5.0 μR/hr to 9.4 μR/hr with an average of 6.5 μR/hr (see Table 3). Some of the "Black Beauty" sand blasting material was obvious on the ground at locations G4, G5, and G6 and contributed to the slightly elevated gamma exposure rates at these locations. These sites not excluded, the average was in the range of normal background for other Gulf Coast towns, for example, Crystal River, Florida, 5.9 μR/hr, Venice, Florida, 6.6 μR/hr, Port Richey, Florida, 7.7 μR/hr, and Inglis, Florida, 6.2 μR/hr (Le68).

Table 1

Results of Aquatic Life Sample Gamma Analyses

Sample Type	Collection[1] Location	Radionuclide	Specific Gamma Activity (pCi/gm wet weight)
Oysters (background sample)	Pascagoula River-N of U.S. 90 Bridge	^{40}K	1.6 ± 18%
Oysters	Pier No. 4	^{40}K	1.8 ± 11%
Assorted small fish, shrimp	Pascagoula River-N of U.S. 90 Bridge	^{40}K	2.9 ± 10%
Assorted small fish	Pascagoula River-N of U.S. 90 Bridge	^{40}K	2.5 ± 11%
Crabs	SW of Dock No. 4	^{40}K	1.1 ± 50%
		^{137}Cs	0.02 ± 65%
		^{232}Th	0.12 ± 92%

[1]Site locations are approximate, since these are aquatic life samples collected underwater.

Table 2

Results of Water Sample Analyses

Location[1]	Radionuclide[2]	Activity (pCi/l)
Site B-1	^{214}Pb	38 ± 62%
	^{214}Bi	54 ± 43%
Site 4	^{40}K	200 ± 53%
Site 13	^{40}K	180 ± 80%
	^{214}Pb	42 ± 53%
	^{214}Bi	44 ± 52%
Site 18	^{40}K	160 ± 89%
	^{214}Pb	33 ± 69%
	^{214}Bi	31 ± 70%
Site 22	^{40}K	240 ± 48%
Site 27	^{40}K	170 ± 85%
Site 32		NDA[3]

[1]Locations (sites) shown in Figs. 2 and 3.

[2]The only radionuclides with detectable activity in the sample are those listed in Table 2. All are naturally occurring members of the uranium and thorium decay series plus K-40.

[3]No detectable activity (NDA).

Table 3

Gamma Shoreline Measurements
PIC Data

Location [1]	Exposure Rate (μR/hr)
G1	5.1
G2	7.6
G3	5.2
G4	8.6
G5	9.0
G6	9.4
G7	6.5
G8	7.0
G9	8.0
G10	5.5
G11	5.2
G12	7.0
G13	6.0
G14	5.5
G15	5.5
G16	5.0
G17	5.0

[1]Locations (sites) shown in Fig. 5.

Survey of Submarine Overhaul and Refueling Building (SORB) and Miscellaneous Areas

Extensive samples of surface materials were taken to evaluate the extent of the contamination of the SORB. A gamma analysis was done on paint samples at 92 sites and concrete samples at 12 sites identified in Appendix 3. Paint samples with detectable activity are shown in Table 4.

Residual Co-60 fixed contamination was found on painted surfaces at several sites, but all levels were well below the NAVSEA limit of 30 pCi/gram (Co-60 equivalent) for bulk material (earth, ground covering, paint, or building materials). The highest Co-60 level measured in paint was 4 pCi/gm. The added exposure to personnel from this residual contamination would be insignificant to individuals who may work in a room containing Co-60 at this level. For example, if an individual ingested 50 grams of paint containing Co-60 at a concentration of 4 pCi/gm, the dose equivalent commitment to the lower large intestine wall would only be 0.008 mrem. Dose equivalent commitments to other target organs would be smaller. The highest paint sample contained 14 pCi of Co-60 (4 pCi/gm x 3.5 gms). If the 14 picocuries of Co-60 were spread over a 100 cm^2 surface area, an individual would receive about 0.07 mrem/yr external exposure if he spent 40 hours per week every week of the year adjacent to this surface. For an individual to receive this exposure, surrounding surfaces would also have to be contaminated at the 0.14 pCi/cm^2 level. Actual exposures would be much less to individuals spending only a small fraction of their time in areas with residual Co-60 contamination.

A sample of paint from room 114 contained a trace amount of Cr-51 (1.6 pCi/g $\pm$ 86%). Due to the short half-life of Cr-51, it is not credible that this activity remained from nuclear operations conducted in the rooms. The activity reported is very near background and probably resulted from inaccuracies in the spectrum analysis program used.

Concrete samples were taken at 12 sites (identified in Appendix 3) and analyzed for gamma emitters. Except for a small amount of Co-60 found in rooms 138 and 223, radionuclides detected were naturally occurring at ambient levels. Results of the concrete sample gamma analyses are shown in Table 5.

Forty-three smear samples were taken and counted with a low background beta counter to check for removable beta surface contamination (see Table 6). Eight additional smears were taken using millipore HAWP 4700 filter paper and counted with a liquid scintillation counter to check for removable tritium surface contamination (see Table 7). No removable surface contamination was detected with the smears. Also, a survey was made in several of the rooms with a portable alpha survey meter, and no alpha contamination was found during this survey.

Air samples were collected at several locations using a 4-inch MSA dust filter. The volume of air sampled was approximately 1800 m^3. No detectable gamma activity above natural background was observed on any of the filters. The sampling sites are listed in Table 8 and are shown in Appendix 3. No airborne moisture samples collected on drierite columns contained detectable tritium.

Soil samples were collected at several locations under the SORB and other shipyard sites. Activity found in the soil was attributed to fallout, naturally occuring radionuclides, and trace amounts of Co-60 (see Table 9).

Samples were collected from the SORB wall insulation and from the abrasive (Black Beauty) used in sand blasting. Only natural radionuclides were found in these materials (see Table 10).

Asphalt samples were taken at three locations because of positive readings on the survey instruments. However, results indicated that the readings were due to natural radioactivity (see Table 11).

Gamma radiation measurements were made at several locations using a pressurized ionization chamber. Measurements from the SORB (Table 12), power unit travel routes (Table 13), and other miscellaneous shipyard areas (Table 14) were all in the range of normal background for that area.

Table 4

Paint Samples with Detectable Gamma Activities

Location[1]	Radionuclide	Activity (pCi/gm dry weight)
Rm 106, grid F-8 (Site 1)	^{60}Co	0.97 ± 31%
Rm 109, grid F-27 (Site 2)	^{58}Co	0.06 ± 73%
	^{60}Co	0.43 ± 62%
Rm 111, grid F-8 (Site 3)	^{60}Co	3.1 ± 18%
	^{60}Co	4.0 ± 14%
Rm 114, grid F-7 (under calibrator rail) (Site 4)	^{51}Cr	1.6 ± 86%
Rm 115, grid F-26 (Site 5)	^{60}Co	0.63 ± 50%
Rm 115, grid SW-13 (Site 6W)	^{60}Co	0.55 ± 56%
Rm 118, grid F-39 (Site 7)	^{40}K	4.5 ± 84%
	^{60}Co	0.37 ± 74%
Rm 119, grid F-13 (Site 8)	^{60}Co	1.30 ± 34%
Rm 119, grid F-19 (Site 9)	^{60}Co	1.30 ± 34%
	^{60}Co	1.40 ± 26%
	^{137}Cs	0.30 ± 75%
Rm 131, grid F-25 (Site 10)	^{60}Co	0.42 ± 86%
Rm 133, grid F-27 (Site 11)	^{60}Co	0.23 ±114%

[1]Location identified on drawings in Appendix 3

Table 4--Continued

Paint Samples with Detectable Gamma Activities

Location	Radionuclide	Activity (pCi/gm dry weight)
Rm 134, grid F-16 (Site 12)	^{60}Co	1.3 ± 27%
Rm 134, grid F-41 (Site 13)	^{60}Co	4.0 ± 21%
	^{60}Co	3.5 ± 16%
Rm 137, grid F-18 (Site 14)	^{60}Co	3.30 ± 22%
Rm 138, grid F-27 (Site 15)	^{137}Cs	0.43 ± 64%
Rm 138, grid F-42 (Site 16)	^{60}Co	0.40 ± 91%
Rm 139, grid F-226 (Site 17)	^{214}Pb	2.6 ± 33%
	^{214}Bi	2.2 ± 45%
Rm 139, grid F-239 (Site 18)	^{60}Co	0.42 ± 66%
Rm 139, grid F-310 (Site 19)	^{60}Co	0.47 ± 56%
Rm 140, grid WW-11 (Site 20)	^{60}Co	0.27 ±124%
Rm 140, grid F-8 (Site 21)	^{60}Co	0.75 ± 60%
	^{58}Co	0.15 ± 83%
	^{60}Co	0.73 ± 40%
Rm 141, grid F-2 (Site 22)	^{60}Co	1.5 ± 39%
	^{214}Pb	3.9 ± 32%
	^{214}Bi	4.2 ± 34%

Table 4--Continued

Paint Samples with Detectable Gamma Activities

Location	Radionuclide	Activity (pCi/gm dry weight)
Rm 143, grid F-34 (Site 23)	^{137}Cs	0.15 ± 49%
Rm 143, grid F-76 (Site 24)	^{60}Co	0.96 ± 49%
Rm 143, grid F-162 (Site 25)	^{60}Co	1.2 ± 44%
Rm 207 east, grid F-4 (Site 26)	^{60}Co	0.88 ± 56%
Rm 223, grid EW-8 (Site 27)	^{214}Pb	1.5 ± 55%
	^{214}Bi	1.8 ± 54%

Table 5

Gamma Activity in Concrete Samples

Location	Radionuclide	Activity (pCi/gm dry weight)
Rm 109, grid F-5 (sump G) (Site 28)	^{40}K	0.80 ± 52%
Rm 116, grid F-26 (Site 29)	^{40}K	1.00 ± 86%
Rm 129, grid F035 (including cervice) (Site 30)	^{40}K	0.48 ± 96%
	^{40}K	0.56 ± 68%
	^{214}Pb	0.12 ± 61%
	^{214}Bi	0.14 ± 62%
	^{232}Th	0.26 ± 43%
Rm 138, grid F-2 (center) (Site 31)	^{60}Co	0.04 ±102%
Rm 138, grid F-111 (Site 32)	^{40}K	0.94 ± 73%
Rm 138, grid WW-6 (at anchors) (Site 33)	^{214}Pb	0.35 ± 37%
	^{214}Bi	0.35 ± 45%
	^{232}Th	0.19 ± 85%
Rm 139, grid SW-58 (cervice) (Site 34)	^{214}Pb	0.32 ± 29%
	^{214}Bi	0.35 ± 40%
	^{232}Th	0.23 ± 97%
Rm 142, grid F-2 (adjacent to area decontaminated by concrete removal) (Site 35)	^{40}K	0.74 ± 84%
Rm 215, grid F-26 (Site 36)	^{40}K	0.81 ± 77%

Table 5--Continued

Gamma Activity in Concrete Samples

Location	Radionuclide	Activity (pCi/gm dry weight)
Rm 222, grid F-136 (around ventilation ducting) (Site 37)	^{214}Pb	0.33 ± 33%
	^{214}Bi	0.38 ± 31%
	^{232}Th	0.25 ± 54%
Rm 223, grid F-9 and adjacent grids (around ventilation penetration) (Site 38)	^{214}Pb	0.31 ± 33%
	^{214}Bi	0.31 ± 38%
	^{232}Th	0.21 ± 55%
Rm 223, grid F-72 (around area decontaminated by concrete removal) (Site 39)	^{60}Co	0.39 ± 74%

Table 6

Surface Contamination Sampling Sites for Beta Analyses

Location	Location
Metrology Lab, granite table	Rm 110, sump G(F5) and duct between C14-C8
Rad Services Bldg. M-18, Vent Flue, Rm 8A, Shower Floor	Rm 116, filter return site
Regulated exhaust vent on roof of SORB	Rm 120, F-275, F-2, F-39, duct work on floor, F-106, F-256, and sink
Air Handling Unit 4, exhaust for SORB uncontrolled areas	Rm 122, exhaust
SORB M-1, floor by grinder	Rm 122A
SORB M-3, edge above door on unit 2 compartment #1	Rm 123, exhaust upstream of HEPA
SORB M-3, top of Honeywell Control Box	Rm 128, fume hood duct
SORB M-3, top of chilled water pipe	Rm 134, F-17
Rm 209, F-18, EW-11, door casing by NWS	Rm 138, filter return site, F-144, Nw-63, and floor of sump F
Rm 215, airhandling unit, filter return central (upstream)	Rm 140, F-7, F-6 and exhaust ducting
Rm 222, filter returnsite (F43)	Rm 141, exhaust ducting
Rm 223, exhaust ducting	Rm 143, F-130
Rm 109, sink	

Note. - Locations (sites) shown in Appendix 3.

Table 7

Surface Contamination Sampling Sites for Tritium Analyses

Location
Rm 109, drain plug, and F-28
Rm 110, F-5 (sump G)
Rm 134, F-17
Rm 138, F-5, F-42, F-54, and WW-92

Note. - Locations (sites) shown in Appendix 3.

Table 8

Air Sampling Sites

Beta and Gamma Sampling Sites	Tritium Sampling Sites
Rm 109 (Sump G) (Site 40)	Rm 138, Sump F (Site 46)
Rm 120, F-288 (Site 41)	Rm 138, Sump F (Site 47)
Between Rm 138 and Rm 139 (Site 42)	Rm 209 (Site 48)
Rm 143 (Site 43)	
Rm 209 (Site 44)	
loading dock at tank farm area (Site 45)	

Note. - Sites shown in Appendix 3.

Table 9

Gamma Activity in Soil Samples

Location	Radionuclide[1]	Gamma Activity (pCi/gm dry weight)
Surface soil at grid F-1 (under graving dock hardline penetration)	^{40}K	0.59 ± 22%
	^{214}Pb	0.41 ± 7%
	^{214}Bi	0.40 ± 7%
	^{232}Th	0.43 ± 10%
Surface soil at grid F-8 (at Sump "G" penetration)	^{40}K	0.34 ± 26%
	^{137}Cs	0.014 ± 55%
	^{214}Pb	0.16 ± 12%
	^{214}Bi	0.16 ± 12%
	^{232}Th	0.20 ± 14%
	^{238}U	0.76 ± 100%
Surface soil at grid F-7 (at southwest corner of Sump "G")	^{40}K	0.23 ± 41%
	^{214}Pb	0.19 ± 10%
	^{214}Bi	0.19 ± 10%
	^{232}Th	0.20 ± 14%
Soil sample under SORB adjacent to Sump F at grid F-127 at a depth of = 30 cm	^{40}K	0.20 ± 41%
	^{214}Pb	0.09 ± 21%
	^{214}Bi	0.053 ± 37%
	^{232}Th	0.17 ± 16%

[1]With the exception of Co-60 in four samples, all other radionuclides with detectable activity are naturally occurring members of the uranium and thorium decay chains, K-40, or Cs-137 from nuclear weapons testing.

Table 9--Continued

Gamma Activity in Soil Samples

Location	Radionuclide	Gamma Activity (pCi/gm dry weight)
Soil sample under SORB adjacent to Sump F at grid F-127 at a depth of 1 to 3 cm	^{40}K	0.43 ± 23%
	^{137}Cs	0.008± 99%
	^{214}Pb	0.26 ± 9%
	^{214}Bi	0.25 ± 9%
	^{232}Th	0.28 ± 12%
Surface soil at #10 Headhouse	^{40}K	0.55 ± 19%
	^{137}Cs	0.025± 32%
	^{214}Pb	0.23 ± 8%
	^{214}Bi	0.25 ± 8%
	^{232}Th	0.10 ± 23%
Soil sample in shower drain of the rad. services building	^{40}K	0.54 ± 15%
	^{60}Co	0.02 ± 26%
	^{214}Pb	0.18 ± 10%
	^{214}Bi	0.15 ± 12%
	^{232}Th	0.20 ± 12%
	^{238}U	0.73 ± 79%
Soil sample at #1 Warehouse storage site (west side - inside fenced area)	^{40}K	0.46 ± 24%
	^{137}Cs	0.38 ± 5%
	^{214}Pb	0.12 ± 16%
	^{214}Bi	0.13 ± 15%
	^{232}Th	0.064± 35%

Table 9--Continued

Gamma Activity in Soil Samples

Location	Radionuclide	Gamma Activity (pCi/gm dry weight)
Soil sample at WAY 7 (TRG-427)	^{40}K	3.5 ± 15%
	^{60}Co	0.13 ± 27%
	^{137}Cs	0.08 ± 44%
	^{214}Pb	0.94 ± 9%
	^{214}Bi	0.90 ± 11%
	^{232}Th	0.48 ± 21%
Rm 117, grid F-58 (drit and gravel from railroad bed)	^{60}Co	0.13 ± 42%
	^{60}Co	0.11 ± 39%
	^{40}K	1.00 ± 45%
	^{214}Pb	0.31 ± 26%
	^{214}Bi	0.21 ± 43%
	^{232}Th	0.30 ± 40%
South wingwall (west end storm drain)	^{40}K	0.81 ± 55%
	^{137}Cs	0.14 ± 32%
	^{214}Pb	0.17 ± 48%
	^{214}Bi	0.13 ± 72%
	^{232}Th	0.28 ± 43%
South wingwall (east end storm drain)	^{7}Be	0.48 ± 49%
	^{40}K	1.1 ± 65%
	^{214}Pb	0.35 ± 33%
	^{214}Bi	0.28 ± 47%
	^{232}Th	0.15 ± 85%

Table 9--Continued

Gamma Activity in Soil Samples

Location	Radionuclide	Gamma Activity (pCi/gm dry weight)
Composite soil from the tank farm area	^{40}K	0.63 ± 18%
	^{60}Co	0.055± 17%
	^{137}Cs	0.068± 16%
	^{214}Pb	0.25 ± 11%
	^{214}Bi	0.21 ± 12%
	^{232}Th	0.26 ± 13%
	^{238}U	1.1 ± 72%
	^{106}Ru	0.11 ± 54%

Table 10

Results of Miscellaneous Sample Analyses

Location and Type of Sample	Type of Analysis	Radionuclide[1]	Activity (pCi/gm)
Rm 117, grid EW-26 (wall material - insulation)	gamma	all	0.00 ± 0%
Black Beauty (used in sand blasting)	gamma	^{40}K	13.0 ± 7%
		^{214}Pb	4.6 ± 4%
		^{214}Bi	3.9 ± 3%
		^{232}Th	1.4 ± 13%
		^{238}U	1.4 ± 50%
	Ra (Rn emanation into Lucas cell)	^{226}Ra	5.2 ± 2%(ash)
		^{226}Ra	4.2 ± 2%(wet)
	U (alpha spectroscopy)	^{234}U	3.4 ± 12%(ash)
		^{235}U	0.36 ± 19%(ash)
		^{238}U	3.9 ± 12%(ash)
		^{234}U	2.8 ± 12%(wet)
		^{235}U	2.9 ± 19%(wet)
		^{238}U	3.2 ± 12%(wet)
	Th (alpha spectroscopy)	^{227}Th	0.35 ± 21%(ash)
		^{238}Th	1.1 ± 11%(ash)
		^{230}Th	3.8 ± 8%(ash)
		^{232}Th	1.1 ± 10%(ash)
		^{227}Th	0.28 ± 20%(wet)
		^{228}Th	0.92 ± 11%(wet)
		^{230}Th	3.0 ± 8%(wet)
		^{232}Th	0.92 ± 10%(wet)

[1]All radionuclides with detectable activity reported in Table 10 are naturally occurring.

Table 11

Results of Asphalt Sample Gamma Analyses

Location	Radionuclide[1]	Gamma Activity (pCi/gm dry weight)
Warehouse #1 (west side - outside fenced area)	^{40}K	1.1 ± 51%
	^{137}Cs	0.038 ± 99%
	^{214}Pb	0.23 ± 38%
	^{214}Bi	0.24 ± 41%
	^{232}Th	0.38 ± 36%
Metrology - (east side - outside door)	^{40}K	5.8 ± 17%
	^{214}Pb	1.3 ± 11%
	^{214}Bi	1.1 ± 14%
	^{232}Th	2.5 ± 11%
Between rad. services building and hospital	^{40}K	8.1 ± 4%
	^{214}Pb	1.3 ± 4%
	^{214}Bi	1.2 ± 6%
	^{232}Th	3.2 ± 3%
	^{238}U	2.1 ± 71%

[1]All radionuclides with detectable activity reported in Table 11 are naturally occurring except Cs-137 from weapons testing.

Table 12

External Gamma Radiation Measurements Inside Submarine Overhaul and Refueling Building (SORB)

Location (Room)	Reading μ R/hr (average)
104	5.6
105	6.7
106	6.4
107	6.5
108	5.6
109	5.2
110	5.5
111	7.3
112	6.2
114	5.6
115	4.6
116	4.5
117	4.0
118	5.8
119	6.0
120	5.8
121	6.0
122	5.3
122A	4.7
123	6.6
124	6.2
125	5.8
126	4.7
127	5.4
128	5.2
129	6.1
130	7.1

Table 12--Continued

External Gamma Radiation Measurements Inside Submarine Overhaul and Refueling Building (SORB)

Location (Room)	Reading μ R/hr (Average)
131	6.5
133	5.1
134	5.9
135	5.1
136	5.3
137	5.2
138	4.8
138A	4.5
139	4.6
140	5.4
141	5.6
142	5.3
143	5.7
144	6.6
145	7.1
146	6.1
209	5.5
213	6.9
222	5.0
223	5.6

Table 13

Travel Routes for Power Units

Location	Reading μ R/hr (Average)
Warehouse	5.5
No. 8 Head house	4.0
8 Dock	4.0
Pier 7	4.4
Pier 1	5.3
Transportation Building	5.4
No. 4 Tool room	4.7
9C Substation	4.9
East End of SORB	4.5

Table 14

Gamma Measurements in Other Shipyard Locations

Location	Reading μ R/hr (Average)
Storage area where spent fuel cars were worked on	6.0
Resin storage area	7.0
Graving dock	5.0
Electric shop	4.0
Metrology building	6.5
Graving dock	3.5
Roof of SORB	4.0
West end storage area	4.0
North wing wall of graving dock	3.5
No. 10 Head House	6.0
Radiation Service Building Room	
1	4.0
3	4.0
5	4.0
6	4.5
7	4.5
8	4.5
8a	5.5
9	5.5

V. CONCLUSIONS

The radiological survey of the Ingalls Shipbuilding Division provided the basis for the following conclusions.

1. The procedures used to control the releases of radioactive materials into the harbor have been effective.

2. Levels of activity measured in the harbor are close to the minimum detection limit for most equipment. Except for a trace amount of Co-60 measured at one sediment sampling site, the only radionuclides detected are those attributable to fallout and those which are naturally occurring.

3. The only shoreline gamma exposure rates which are elevated above background are attributable to sandblasting material on the ground at these locations.

4. The levels of radioactivity found by EPA in the survey at Ingalls Shipbuilding Division, Pascagoula, Mississippi, do not constitute a detriment to the environment nor a significant radiation exposure to the public or shipyard employees.

5. The Submarine Overhaul and Refueling Building (SORB) has been decontaminated by Ingalls prior to converting this building to non-nuclear use. Residual levels of Co-60 contamination were found, but all levels were well below the NAVSEA limit of 30 pCi/gm (Co-60 equivalent) for bulk material (earth, ground coverings, paint, or building materials). The radiation dose to individuals from these residual levels of Co-60 contamination are estimated to be extremely small. However, in keeping with the concept of reducing radiation doses to as low as reasonably achievable, it would be prudent to remove from possible human contact those materials with detectable levels which are easily removable.[1]

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[1]Subsequent to the December 7-11, 1981 decommissioning surveys, Ingalls Shipbuilding decontaminated painted surfaces containing residual Cobalt 60 activity. "Sample analysis results of eighty-two grids (rooms 115, 118, 120, 134, 136, 137, 138, 140, 141, and 209) indicated residual Cobalt 60 below NAVSEA criteria but above minimum detectable activity (MDA). The surface layer was removed on these grids and subsequent sample analysis results were less than MDA of approximately 3×10^{-6} µCi/gm (3 pCi/gm). Sample analysis results of four grids in room 117 indicated residual Cobalt 60 below NAVSEA criteria but above 1×10^{-6} µCi/gm (1 pCi/gm) (concrete and crevice). The surface layer was removed from these grids and subsequent sample analysis results were less than 1×10^{-6} µCi/gm." From Deactivation of Ingalls Radiological Facilities, Volume 1, page 68, Ingalls Shipbuilding Division, Litton Industries, Pascagoula, Mississippi, 1982.

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Appendix 1

Results of Sediment Sample Analyses

Location	Radionuclide[2]	Activity (pCi/gm dry weight)
Site B-1[1]	^{40}K	2.5 ± 8%
	^{137}Cs	0.098 ± 13%
	^{106}Ru	0.079 ± 63%
	^{214}Pb	0.21 ± 13%
	^{214}Bi	0.19 ± 12%
	^{232}Th	0.23 ± 16%
Site 2	^{40}K	0.85 ± 10%
	^{214}Pb	0.11 ± 13%
	^{214}Bi	0.087 ± 17%
	^{232}Th	0.11 ± 15%
	^{238}U	0.76 ± 60%
Site 4	^{40}K	2.1 ± 11%
	^{137}Cs	0.07 ± 20%
	^{214}Pb	0.26 ± 13%
	^{214}Bi	0.18 ± 16%
	^{232}Th	0.14 ± 27%
Site 6	^{40}K	0.85 ± 12%
	^{137}Cs	0.024 ± 28%
	^{214}Pb	0.17 ± 9%
	^{214}Bi	0.15 ± 11%
	^{232}Th	0.13 ± 18%

[1]Sites locations are shown in Fig. 3.

[2]With the exception of Co-60 at Site 31 and Cs-137 fallout from weapons testing, all radionuclides reported are naturally occurring members of the uranium and thorium decay chains or K-40. No other detectable activity was present.

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 8	^{40}K	2.3 ± 9%
	^{137}Cs	0.063 ± 19%
	^{214}Pb	0.15 ± 14%
	^{214}Bi	0.16 ± 14%
	^{232}Th	0.11 ± 27%
Site 9	^{40}K	2.3 ± 8%
	^{137}Cs	0.078 ± 15%
	^{106}Ru	0.075 ± 70%
	^{214}Pb	0.13 ± 16%
	^{214}Bi	0.12 ± 17%
	^{232}Th	0.13 ± 23%
Site 10	^{40}K	2.0 ± 8%
	^{137}Cs	0.058 ± 19%
	^{106}Ru	0.015 ± 97%
	^{214}Pb	0.13 ± 15%
	^{214}Bi	0.13 ± 15%
	^{232}Th	0.12 ± 23%
Site 11	^{40}K	2.7 ± 6%
	^{137}Cs	0.049 ± 17%
	^{214}Pb	0.18 ± 10%
	^{214}Bi	0.15 ± 14%
	^{232}Th	0.22 ± 13%
	^{238}U	0.90 ± 77%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 13	^{40}K	2.4 ± 8%
	^{137}Cs	0.075 ± 17%
	^{214}Pb	0.14 ± 18%
	^{214}Bi	0.14 ± 16%
	^{232}Th	0.15 ± 21%
Site 14	^{40}K	2.0 ± 7%
	^{137}Cs	0.041 ± 19%
	^{106}Ru	0.058 ± 89%
	^{214}Pb	0.14 ± 16%
	^{214}Bi	0.08 ± 66%
	^{232}Th	0.18 ± 14%
Site 15	^{40}K	2.0 ± 9%
	^{137}Cs	0.043 ± 23%
	^{214}Pb	0.29 ± 9%
	^{214}Bi	0.27 ± 9%
	^{232}Th	0.22 ± 12%
Site 16	^{40}K	1.6 ± 9%
	^{137}Cs	0.023 ± 35%
	^{214}Pb	0.29 ± 7%
	^{214}Bi	0.29 ± 8%
	^{232}Th	0.29 ± 14%
Site 17	^{40}K	2.4 ± 7%
	^{137}Cs	0.051 ± 18%
	^{214}Pb	0.09 ± 21%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 17 (continued)	^{214}Bi	0.49 ± 41%
	^{232}Th	0.17 ± 16%
	^{238}U	0.80 ± 96%
Site 18	^{40}K	2.4 ± 8%
	^{137}Cs	0.064 ± 18%
	^{214}Pb	0.29 ± 8%
	^{214}Bi	0.28 ± 9%
	^{232}Th	0.20 ± 16%
Site 19	^{40}K	1.3 ± 8%
	^{137}Cs	0.018 ± 35%
	^{214}Pb	0.17 ± 10%
	^{214}Bi	0.15 ± 12%
	^{232}Th	0.19 ± 12%
Site 20	^{40}K	2.2 ± 13%
	^{137}Cs	0.062 ± 19%
	^{106}Ru	0.082 ±107%
	^{214}Pb	0.20 ± 12%
	^{214}Bi	0.19 ± 16%
	^{232}Th	0.16 ± 29%
Site 21	^{40}K	2.5 ± 8%
	^{137}Cs	0.074 ± 17%
	^{214}Pb	0.25 ± 10%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 21 (continued)	^{214}Bi	0.24 ± 10%
	^{232}Th	0.18 ± 19%
Site 22	^{40}K	2.4 ± 8%
	^{137}Cs	0.06 ± 19%
	^{214}Pb	0.17 ± 12%
	^{214}Bi	0.16 ± 14%
	^{232}Th	0.16 ± 20%
Site 23	^{40}K	2.4 ± 13%
	^{137}Cs	0.072 ± 21%
	^{214}Pb	0.17 ± 14%
	^{214}Bi	0.17 ± 18%
	^{232}Th	0.14 ± 35%
Site 24	^{40}K	2.7 ± 8%
	^{137}Cs	0.07 ± 21%
	^{214}Pb	0.17 ± 16%
	^{214}Bi	0.15 ± 14%
	^{232}Th	0.16 ± 20%
Site 25	^{40}K	2.1 ± 9%
	^{106}Ru	0.057 ± 96%
	^{137}Cs	0.072 ± 16%
	^{214}Pb	0.17 ± 13%
	^{214}Bi	0.16 ± 14%
	^{232}Th	0.14 ± 21%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 26	^{40}K	2.2 ± 6%
	^{137}Cs	0.047 ± 17%
	^{214}Pb	0.22 ± 9%
	^{214}Bi	0.18 ± 12%
	^{232}Th	0.19 ± 13%
Site 27	^{40}K	2.7 ± 8%
	^{137}Cs	0.076 ± 16%
	^{214}Pb	0.19 ± 12%
	^{214}Bi	0.16 ± 14%
	^{232}Th	0.17 ± 19%
Site 28	^{40}K	2.3 ± 7%
	^{137}Cs	0.058 ± 17%
	^{106}Ru	0.067 ± 66%
	^{214}Pb	0.081 ± 24%
	^{214}Bi	0.042 ± 50%
	^{232}Th	0.14 ± 18%
Site 29	^{40}K	2.3 ± 9%
	^{137}Cs	0.075 ± 16%
	^{106}Ru	0.076 ± 85%
	^{214}Pb	0.21 ± 10%
	^{214}Bi	0.21 ± 13%
	^{232}Th	0.18 ± 19%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 30	^{40}K	0.92 ± 12%
	^{137}Cs	0.012 ± 56%
	^{214}Pb	0.31 ± 6%
	^{214}Bi	0.31 ± 7%
	^{232}Th	0.21 ± 18%
	^{238}U	1.0 ± 78%
Site 31	^{40}K	1.90 ± 8%
	^{60}Co	0.013 ± 45%
	^{137}Cs	0.11 ± 10%
	^{214}Pb	0.12 ± 17%
	^{214}Bi	0.077 ± 29%
	^{232}Th	0.20 ± 14%
	^{238}U	1.4 ± 69%
Site 32	^{40}K	2.0 ± 15%
	^{137}Cs	0.074 ± 19%
	^{214}Pb	0.17 ± 16%
	^{214}Bi	0.12 ± 29%
	^{232}Th	0.16 ± 35%
Site 34	^{40}K	2.7 ± 8%
	^{137}Cs	0.078 ± 14%
	^{214}Pb	0.18 ± 11%
	^{214}Bi	0.16 ± 14%
	^{232}Th	0.19 ± 18%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 37	^{40}K	2.3 ± 8%
	^{137}Cs	0.072 ± 17%
	^{106}Ru	0.066 ± 80%
	^{214}Pb	0.22 ± 11%
	^{214}Bi	0.21 ± 11%
	^{232}Th	0.16 ± 20%
Site 38	^{40}K	2.3 ± 7%
	^{137}Cs	0.048 ± 20%
	^{106}Ru	0.05 ± 91%
	^{214}Pb	0.083 ± 23%
	^{214}Bi	0.048 ± 42%
	^{232}Th	0.16 ± 17%
Site 39	^{40}K	1.9 ± 15%
	^{137}Cs	0.068 ± 20%
	^{214}Pb	0.16 ± 16%
	^{214}Bi	0.16 ± 20%
	^{232}Th	0.18 ± 28%
Site 40	^{40}K	2.3 ± 8%
	^{137}Cs	0.072 ± 16%
	^{214}Pb	0.18 ± 11%
	^{214}Bi	0.18 ± 13%
	^{232}Th	0.22 ± 16%

Appendix 1--Continued

Results of Sediment Sample Analyses

Location	Radionuclide	Activity (pCi/gm dry weight)
Site 41	^{40}K	2.2 ± 9%
	^{137}Cs	0.066 ± 19%
	^{214}Pb	0.20 ± 12%
	^{214}Bi	0.17 ± 14%
	^{232}Th	0.15 ± 21%
Site 42	^{40}K	2.3 ± 7%
	^{137}Cs	0.051 ± 19%
	^{214}Pb	0.081 ± 25%
	^{214}Bi	0.039 ± 55%
	^{232}Th	0.14 ± 19%

Appendix 2

Results of Core Sample Analyses

Location[1]	Depth Below Sediment Water Interface (cm)	Radionuclide[2]	Activity (pCi/gm wet weight)
Core #1	0 - 5.1	^{40}K	1.2 ± 26%
		^{232}Th	1.3 ± 41%
	5.1 - 10.2	^{40}K	3.2 ± 29%
		^{137}Cs	.12 ± 44%
		^{232}Th	.17 ± 82%
	10.2 - 15.2	^{40}K	2.5 ± 37%
		^{232}Th	.18 ± 82%
	15.2 - 20.3	^{40}K	2.5 ± 32%
		^{232}Th	.27 ± 60%
	20.3 - 25.4	^{40}K	3.1 ± 24%
		^{137}Cs	.13 ± 34%
		^{232}Th	.26 ± 49%
	25.4 - 30.5	^{40}K	2.2 ± 30%
		^{137}Cs	0.06 ± 78%
		^{232}Th	.19 ± 65%
Core #2	0 - 5.1	^{40}K	2.1 ± 21%
		^{232}Th	.15 ± 53%

[1]Site locations are shown on Fig. 4.

[2]All radionuclides reported in this appendix are either naturally occurring members of the uranium and thorium decay chains, naturally occurring K-40, or Cs-137 fallout from nuclear weapons testing. No other detectable activity was present.

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #2 (continued)	5.1 - 10.2	^{40}K	2.8 ± 32%
		^{137}Cs	.07 ± 70%
		^{232}Th	.23 ± 71%
	10.2 - 15.2	^{40}K	2.6 ± 37%
		^{137}Cs	.07 ± 92%
	15.2 - 20.3	^{40}K	2.2 ± 35%
	20.3 - 25.4	^{40}K	2.3 ± 44%
		^{137}Cs	.12 ± 40%
		^{232}Th	.28 ± 71%
	25.4 - 30.5	^{40}K	2.7 ± 25%
		^{137}Cs	.11 ± 36%
	30.5 - 35.6	^{40}K	2.3 ± 32%
		^{232}Th	.21 ± 63%
	35.6 - 40.6	^{40}K	2.2 ± 28%
		^{232}Th	.24 ± 54%
	40.6 - 45.7	^{40}K	1.4 ± 39%
		^{137}Cs	.05 ± 89%
		^{232}Th	.13 ± 87%
Core #3	0 - 7.6	^{40}K	2.4 ± 37%
		^{137}Cs	.06 ±101%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #3 (continued)	7.6 - 12.7	^{40}K	2.6 ± 30%
		^{232}Th	.22 ± 63%
	12.7 - 17.8	^{40}K	2.2 ± 47%
		^{137}Cs	.09 ± 51%
		^{232}Th	.24 ± 85%
	17.8 - 22.9	^{40}K	2.1 ± 30%
		^{137}Cs	.07 ± 76%
		^{232}Th	.15 ± 83%
	22.9 - 27.9	^{40}K	2.4 ± 33%
		^{137}Cs	.08 ± 70%
	27.9 - 33.0	^{40}K	2.3 ± 28%
		^{232}Th	.16 ± 97%
	33.0 - 38.1	^{40}K	2.7 ± 35%
		^{137}Cs	.10 ± 54%
		^{232}Th	.17 ± 82%
	38.1 - 43.2	^{40}K	2.5 ± 44%
		^{137}Cs	.07 ± 99%
		^{214}Pb	.37 ± 45%
		^{214}Bi	.48 ± 40%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #3 (continued)	43.2 - 48.3	^{40}K	2.4 ± 37%
		^{232}Th	.24 ± 80%
	48.3 - 53.3	^{40}K	2.5 ± 36%
	53.3 - 58.4	^{40}K	2.2 ± 46%
	58.4 - 63.5	^{40}K	2.5 ± 32%
		^{232}Th	.25 ± 65%
Core #4	0 - 7.6	^{40}K	1.8 ± 37%
		^{137}Cs	.09 ± 49%
		^{214}Pb	.11 ± 74%
		^{214}Bi	.13 ± 74%
	7.6 - 12.7	^{40}K	2.2 ± 43%
	12.7 - 17.8	^{40}K	3.5 ± 28%
	17.8 - 22.9	^{40}K	2.7 ± 32%
		^{137}Cs	.09 ± 57%
		^{232}Th	.18 ± 84%
	22.9 - 27.9	^{40}K	3.5 ± 31%
		^{137}Cs	.10 ± 73%
		^{232}Th	.37 ± 53%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #4 (continued)	27.9 - 33.0	^{40}K	4.4 ± 22%
		^{232}Th	.30 ± 53%
	33.0 - 38.1	^{40}K	4.2 ± 23%
		^{137}Cs	.10 ± 50%
		^{214}Pb	.19 ± 58%
		^{214}Bi	.24 ± 51%
		^{232}Th	.39 ± 43%
	38.1 - 43.2	^{40}K	3.6 ± 30%
		^{137}Cs	.10 ± 67%
		^{232}Th	.39 ± 49%
	43.2 - 48.3	^{40}K	4.2 ± 21%
		^{232}Th	.42 ± 40%
	48.3 - 53.3	^{40}K	3.4 ± 20%
		^{137}Cs	.08 ± 71%
		^{232}Th	.30 ± 54%
	53.3 - 58.4	^{40}K	3.3 ± 25%
		^{232}Th	.33 ± 45%
	58.4 - 63.5	^{40}K	2.8 ± 32%
		^{232}Th	.30 ± 53%
Core #7	0 - 5.1	^{40}K	1.7 ± 40%
		^{232}Th	.50 ± 33%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #7 (continued)	5.1 - 10.2	^{40}K	2.0 ± 40%
		^{137}Cs	.10 ± 51%
		^{214}Pb	.14 ± 81%
		^{214}Bi	.13 ± 85%
		^{232}Th	.28 ± 56%
	10.2 - 15.2	^{40}K	1.8 ± 56%
		^{137}Cs	.15 ± 53%
	15.2 - 20.3	^{40}K	2.2 ± 34%
		^{232}Th	.16 ± 82%
		^{238}U	5.4 ± 78%
	20.3 - 25.4	^{40}K	3.1 ± 32%
		^{232}Th	.19 ± 89%
	25.4 - 30.5	^{40}K	2.7 ± 36%
		^{137}Cs	.07 ± 86%
	30.5 - 35.6	^{40}K	1.8 ± 25%
		^{232}Th	.20 ± 70%
	35.6 - 40.6	^{40}K	2.2 ± 35%
		^{137}Cs	.10 ± 46%
		^{214}Pb	.29 ± 58%
		^{214}Bi	.27 ± 46%
		^{232}Th	.23 ± 69%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #7 (continued)	40.6 - 45.7	^{40}K	1.8 ± 53%
		^{137}Cs	.07 ± 91%
	45.7 - 50.8	^{40}K	1.9 ± 39%
		^{137}Cs	.09 ± 56%
		^{232}Th	.16 ± 77%
Core #8	0 - 8.9	^{40}K	2.1 ± 36%
		^{137}Cs	.07 ± 72%
		^{232}Th	.12 ±103%
	8.9 - 14.0	^{40}K	2.7 ± 33%
		^{137}Cs	.14 ± 44%
		^{232}Th	.18 ± 78%
	14.0 - 19.0	^{40}K	2.2 ± 42%
		^{137}Cs	.11 ± 67%
	19.0 - 24.1	^{40}K	2.0 ± 38%
		^{232}Th	.26 ± 64%
	24.1 - 29.2	^{40}K	2.6 ± 38%
		^{137}Cs	.11 ± 56%
	29.2 - 34.3	^{40}K	1.7 ± 56%
		^{137}Cs	.15 ± 53%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #8 (continued)	34.3 - 39.4	^{40}K	1.6 ± 47%
		^{137}Cs	.12 ± 42%
		^{232}Th	.20 ± 78%
	39.4 - 44.4	^{40}K	2.2 ± 38%
		^{137}Cs	.14 ± 40%
		^{232}Th	.20 ± 79%
	44.4 - 49.5	^{40}K	3.5 ± 38%
		^{137}Cs	.14 ± 68%
		^{232}Th	.23 ± 89%
	49.5 - 54.6	^{40}K	2.7 ± 33%
		^{232}Th	.19 ± 80%
	54.6 - 59.7	^{40}K	3.0 ± 31%
		^{137}Cs	.12 ± 46%
		^{214}Pb	.15 ± 61%
		^{214}Bi	.13 ± 91%
		^{232}Th	.23 ± 58%
	59.7 - 64.8	^{40}K	1.8 ± 52%
		^{137}Cs	.08 ± 83%
		^{232}Th	.16 ± 92%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #10	0 - 5.1	^{40}K	1.8 ± 34%
		^{232}Th	.21 ± 54%
	5.1 - 10.2	^{40}K	2.4 ± 21%
		^{137}Cs	.10 ± 33%
		^{232}Th	.21 ± 46%
	10.2 - 15.2	^{40}K	2.5 ± 25%
		^{137}Cs	.07 ± 65%
		^{214}Pb	.38 ± 26%
		^{214}Bi	.41 ± 26%
		^{232}Th	.22 ± 55%
	15.2 - 20.3	^{40}K	2.3 ± 24%
		^{232}Th	.15 ± 62%
	20.3 - 25.4	^{40}K	4.8 ± 43%
		^{137}Cs	.20 ± 50%
		^{214}Pb	.56 ± 34%
		^{214}Bi	.59 ± 42%
		^{232}Th	.61 ± 69%
	25.4 - 30.5	^{40}K	3.4 ± 19%
		^{137}Cs	.12 ± 32%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #10	0 - 5.1	^{40}K	1.8 ± 34%
		^{232}Th	.21 ± 54%
	5.1 - 10.2	^{40}K	2.4 ± 21%
		^{137}Cs	.10 ± 33%
		^{232}Th	.21 ± 46%
	10.2 - 15.2	^{40}K	2.5 ± 25%
		^{137}Cs	.07 ± 65%
		^{214}Pb	.38 ± 26%
		^{214}Bi	.41 ± 26%
		^{232}Th	.22 ± 55%
	15.2 - 20.3	^{40}K	2.3 ± 24%
		^{232}Th	.15 ± 62%
	20.3 - 25.4	^{40}K	4.8 ± 43%
		^{137}Cs	.20 ± 50%
		^{214}Pb	.56 ± 34%
		^{214}Bi	.59 ± 42%
		^{232}Th	.61 ± 69%
	25.4 - 30.5	^{40}K	3.4 ± 19%
		^{137}Cs	.12 ± 32%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #10 (continued)	30.5 - 35.6	^{40}K	1.5 ± 42%
		^{137}Cs	.09 ± 53%
		^{214}Pb	.21 ± 45%
		^{214}Bi	.21 ± 50%
		^{232}Th	.13 ± 87%
	35.6 - 40.6	^{40}K	2.3 ± 41%
		^{137}Cs	.17 ± 38%
	40.6 - 45.7	^{40}K	2.0 ± 50%
		^{232}Th	.20 ± 81%
	45.7 - 50.8	^{40}K	2.2 ± 26%
		^{232}Th	.20 ± 56%
	50.8 - 55.8	^{40}K	2.7 ± 40%
		^{137}Cs	.07 ± 63%
		^{232}Th	.33 ± 63%
		^{238}U	7.7 ± 91%
	55.8 - 61.0	^{40}K	2.9 ± 20%
		^{137}Cs	.09 ± 39%
		^{232}Th	.14 ± 61%
Core #11	0 - 7.6	^{40}K	1.2 ± 35%
		^{137}Cs	.04 ± 89%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #11 (continued)	7.6 - 12.7	^{40}K	2.1 ± 39%
		^{137}Cs	.09 ± 56%
		^{232}Th	.15 ± 93%
	12.7 - 17.8	^{40}K	2.4 ± 45%
		^{137}Cs	.12 ± 67%
	17.8 - 22.9	^{40}K	2.6 ± 35%
		^{232}Th	.22 ± 83%
	22.9 - 27.9	^{40}K	2.4 ± 44%
		^{137}Cs	.12 ± 43%
		^{214}Pb	.18 ± 48%
		^{214}Bi	.20 ± 67%
		^{232}Th	.26 ± 81%
	27.9 - 33.0	^{40}K	2.5 ± 22%
		^{137}Cs	.12 ± 34%
		^{232}Th	.15 ± 66%
		^{238}U	3.6 ± 97%
	33.0 - 38.1	^{40}K	2.4 ± 30%
		^{137}Cs	.09 ± 56%
		^{232}Th	.13 ± 89%
	38.1 - 43.2	^{40}K	2.8 ± 20%
		^{232}Th	.23 ± 44%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #11 (continued)	43.2 - 48.3	^{40}K	2.8 ± 33%
		^{137}Cs	.10 ± 64%
		^{232}Th	.26 ± 64%
	48.3 - 53.3	^{40}K	2.7 ± 44%
		^{137}Cs	.08 ± 98%
Core #12	0 - 7.6	^{40}K	1.2 ± 37%
		^{232}Th	.32 ± 38%
	7.6 - 12.7	^{40}K	2.0 ± 20%
		^{214}Pb	.15 ± 37%
		^{214}Bi	.15 ± 41%
		^{232}Th	.23 ± 35%
		^{238}U	2.7 ± 90%
	12.7 - 17.8	^{40}K	2.0 ± 25%
		^{214}Pb	.25 ± 28%
		^{214}Bi	.38 ± 39%
		^{232}Th	.18 ± 45%
	17.8 - 22.9	^{40}K	3.3 ± 27%
		^{214}Pb	.19 ± 49%
		^{214}Bi	.19 ± 58%
		^{232}Th	.29 ± 56%

Appendix 2--Continued

Results of Core Sample Analyses

Location	Depth Below Sediment Water Interface (cm)	Radionuclide	Activity (pCi/gm wet weight)
Core #12 (continued)	22.9 - 27.9	^{40}K	3.6 ± 28%
		^{214}Pb	.14 ± 91%
		^{214}Bi	.19 ± 77%
		^{232}Th	.31 ± 56%
	27.9 - 33.0	^{40}K	3.3 ± 25%
		^{232}Th	.38 ± 42%
	33.0 - 38.1	^{40}K	3.9 ± 16%
		^{214}Pb	.19 ± 38%
		^{214}Bi	.19 ± 40%
		^{232}Th	.34 ± 32%
		^{238}U	3.4 ± 90%
	38.1 - 43.2	^{40}K	3.4 ± 15%
		^{232}Th	.28 ± 33%

Appendix 3

Sampling Locations in SORB
East End of SORB - First Floor Paint and Concrete Samples

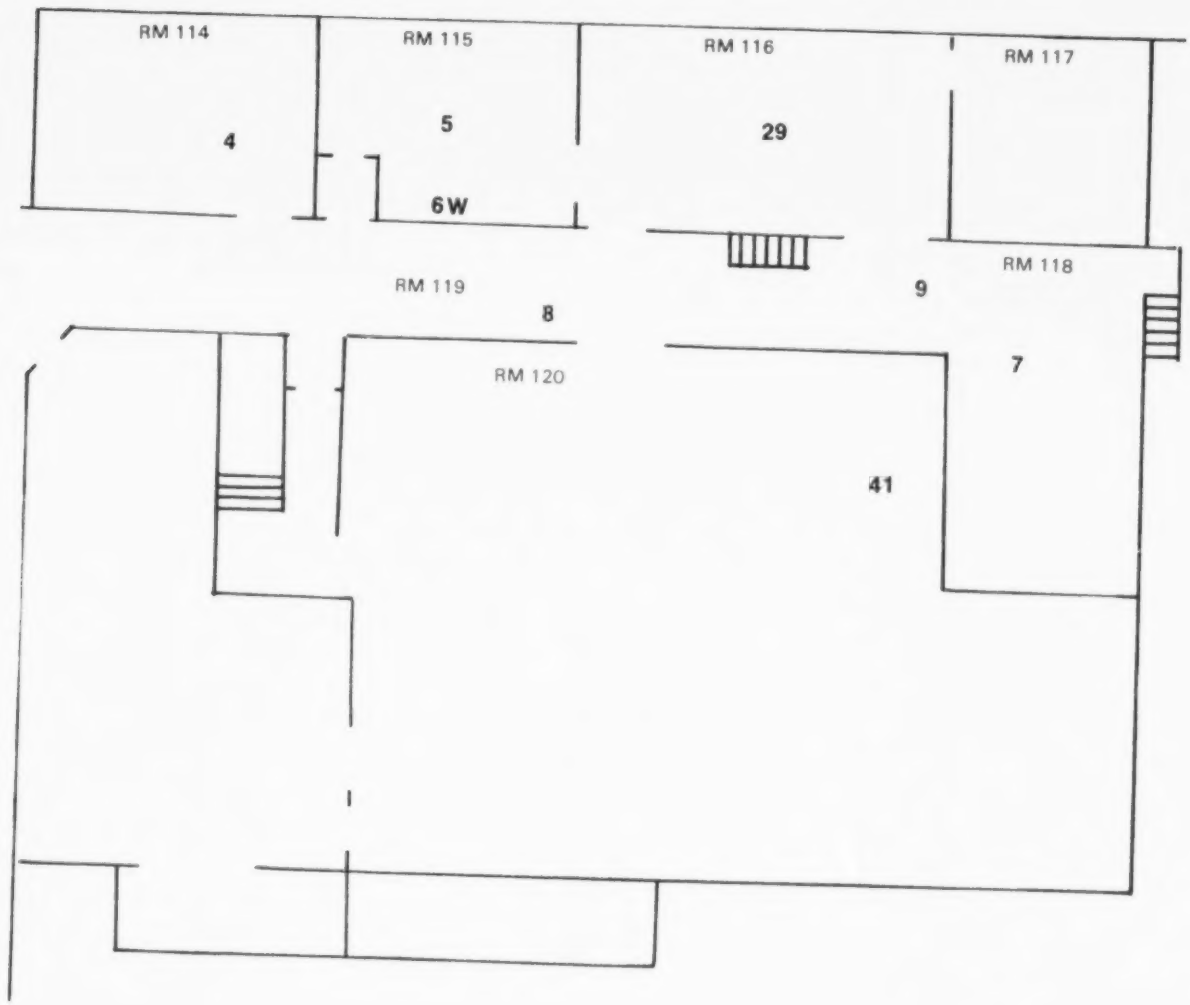

Fig. 6: East End of SORB - First Floor
Paint and Concrete Samples

Appendix 3--continued

Sampling Locations in SORB
West End of SORB - First Floor Paint and Concrete Samples

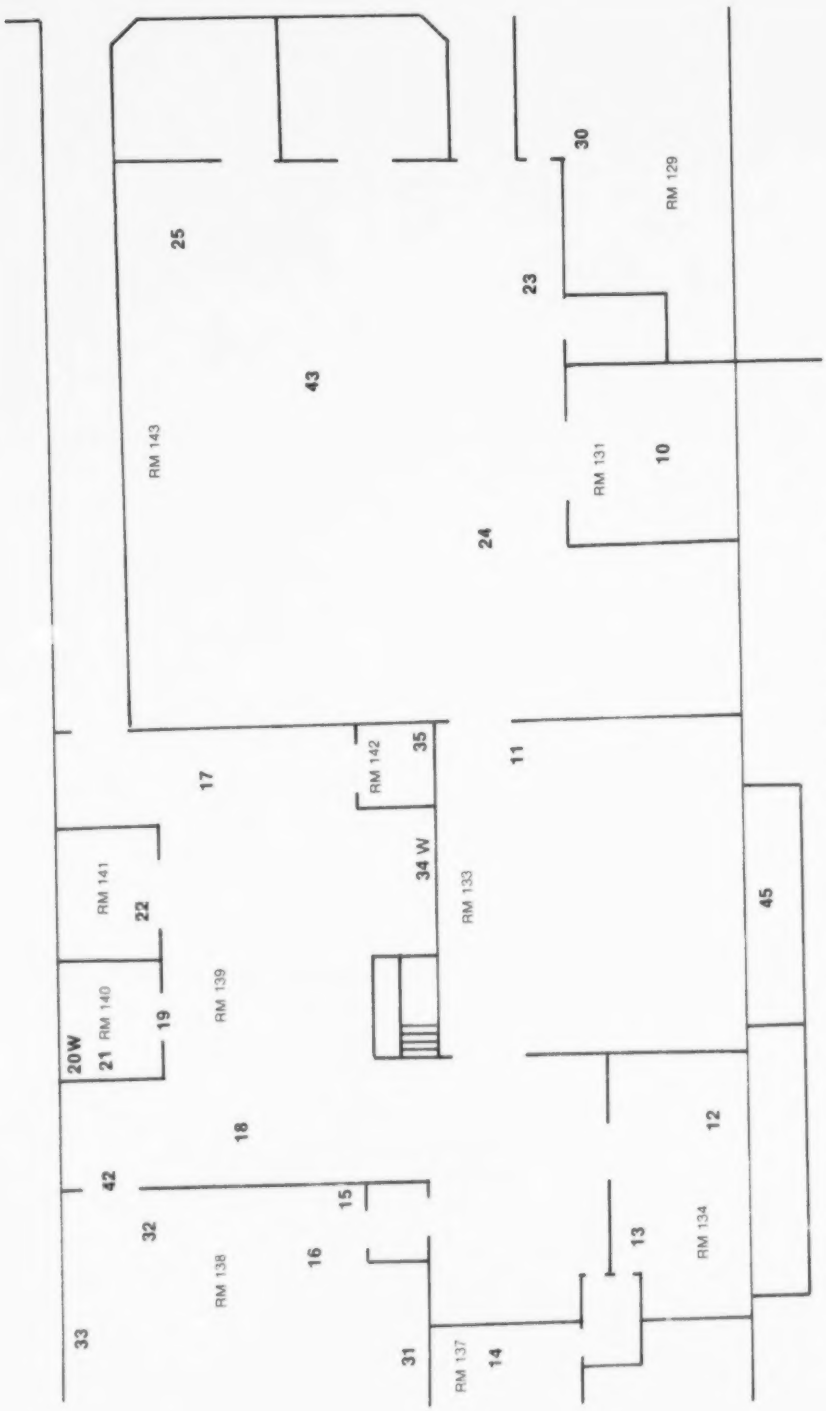

Fig. 7: West End of SORB - First Floor
Paint and Concrete Samples

Appendix 3--continued

Sampling Locations in SORB
Center of SORB - First Floor Paint and Concrete Samples

Fig. 8: Center of SORB - First Floor
Paint and Concrete Samples

Appendix 3--continued

Sampling Locations in SORB
East End of SORB - Second Floor Paint and Concrete Samples

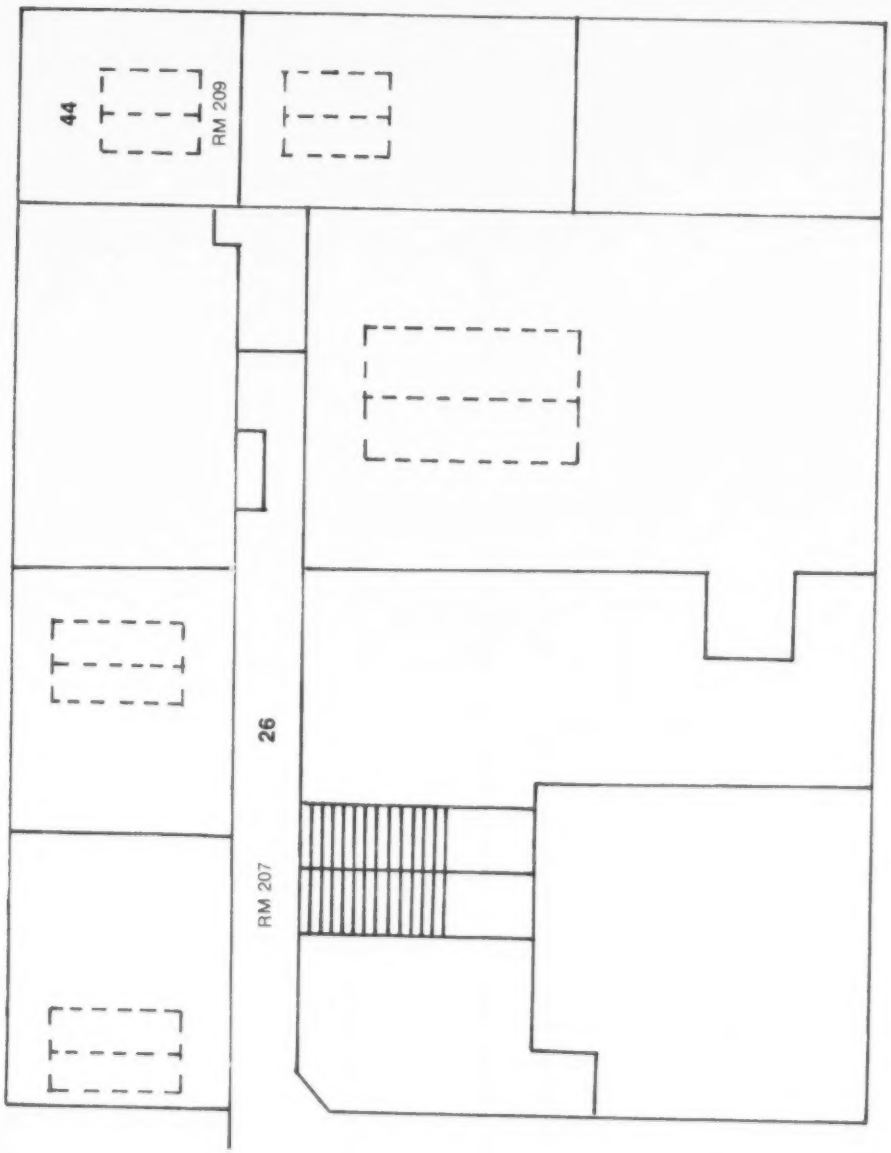

Fig. 9: East End of SORB - Second Floor Paint and Concrete Samples

Appendix 3--continued

Sampling Locations in SORB
Center of SORB - Second Floor Paint and Concrete Samples

Fig. 10: Center of SORB - Second Floor
Paint and Concrete Samples

Appendix 3--continued

Sampling Locations in SORB
West End of SORB - Second Floor Paint and Concrete Samples

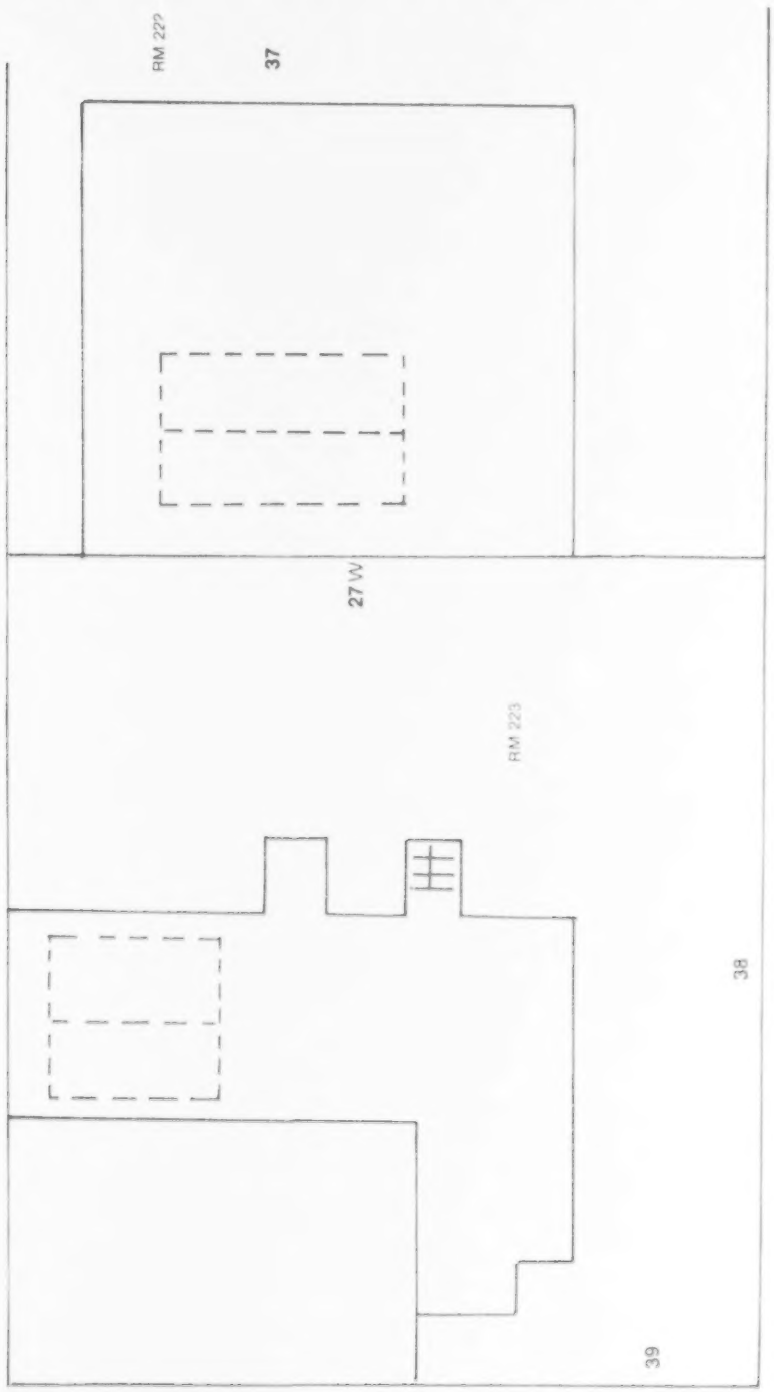

Fig. 11: West End of SORB - Second Floor
Paint and Concrete Samples